

CLAIMS:

1. A liquid electrophotographic toner composition comprising:
 - a) a liquid carrier having a Kauri-butanol number less than 30 mL; and
 - 5 b) a plurality of toner particles dispersed in the liquid carrier, wherein the toner particles comprise polymeric binder comprising at least one amphipathic copolymer comprising one or more S material portions and one or more D material portions, wherein the amphipathic copolymer comprises covalent crosslinking functionality in an amount sufficient to provide a three dimensional gel of controlled
 - 10 rigidity which can be reversibly reduced to a fluid state by application of energy; and wherein the electrophotographic toner composition does not form a film under Photoreceptor Image Formation conditions.
2. The liquid electrophotographic toner composition according to claim 1, wherein
- 15 the crosslinking functionalities are located in the S material portion of the amphipathic copolymer.
3. The liquid electrophotographic toner composition according to claim 1, wherein the crosslinking functionalities are located in the D material portion of the amphipathic
- 20 copolymer.
4. The liquid electrophotographic toner composition according to claim 1, wherein the crosslinking functionalities are located in both the S material portion and the D material portion of the amphipathic copolymer.
- 25 5. The liquid electrophotographic toner composition according to claim 1, said composition comprising a polyfunctional bridging compound having at least two crosslinking functionalities to assist in gel formation.
- 30 6. The liquid electrophotographic toner composition according to claim 1, wherein crosslinking functionalities are provided by incorporation of one or more bifunctional

polymerizable compounds in the amphipathic copolymer, wherein the bifunctional polymerizable compound is selected from the group consisting of divinyl benzene; 1,3 butanediol diacrylate; 1,4 butanediol diacrylate; 1,3 butanediol dimethacrylate; diethylene glycol diacrylate; diethylene glycol dimethacrylate; ethoxylated Bisphenol A diacrylate; 5 ethoxylated Bisphenol A dimethacrylate; ethylene glycol dimethacrylate (EGDMA); 1,6 hexanediol diacrylate; 1,6 hexanediol dimethacrylate; neopentyl glycol diacrylate; neopentyl glycol dimethacrylate; polyethylene glycol diacrylate; polyethylene glycol dimethacrylate; propoxylated neopentyl glycol diacrylate; tetraethylene glycol diacrylate; tetraethylene glycol dimethacrylate; triethylene glycol diacrylate; triethylene glycol 10 dimethacrylate; tripropylene glycol diacrylate; tripropylene glycol dimethacrylate; zinc diacrylate; zinc dimethacrylate and 1,4 phenylene diisocyanate (PDI).

7. The liquid electrophotographic toner composition according to claim 1, wherein crosslinking functionalities are provided by incorporation of one or more bifunctional 15 polymerizable compounds in the amphipathic copolymer, wherein the bifunctional polymerizable compound is selected from the group consisting of t-butylaminoethyl methacrylate; diethylaminoethyl acrylate; diethylaminoethyl methacrylate; 2-diisopropylaminoethyl methacrylate; 2-dimethylaminoethyl methacrylate; dimethylaminopropyl methacrylamide; dipentaerthritol monohydroxypentaacrylate; 2,3- 20 epoxypropyl methacrylate (glycidyl methacrylate); 4-hydroxybutyl acrylate; 2-hydroxyethyl acrylate; 2-hydroxyethyl methacrylate; 2-hydroxypropyl acrylate; cinnamyl alcohol; allyl mercaptan, methallylamine; azlactones, such as 2-alkenyl-4,4-dialkylazlactone; 2-hydroxypropyl methacrylate; meta-isopropenyldimethylbenzyl isocyanate (TMI); isocyanatoethylmethacrylate (IEM); trimethylsilylmethacrylate; 25 (trimethylsilylmethyl)methacrylate; n-vinyl caprolactam; 2-vinyl pyridine; 4-vinyl pyridine and N-vinyl-2-pyrrolidone.

8. The liquid electrophotographic toner composition according to claim 1, wherein crosslinking functionalities are provided by incorporation of one or more trifunctional 30 polymerizable compounds in the amphipathic copolymer, wherein the trifunctional polymerizable compound is selected from the group consisting of ethoxylated

trimethylolpropane triacrylate; glyceryl propoxy triacrylate; pentaerythritol triacrylate; trimethylolpropane triacrylate; trimethylolpropane trimethacrylate (TMPTMA); and tris(2-hydroxyethyl)isocyanurate triacrylate).

5 9. The liquid electrophotographic toner composition according to claim 1, wherein crosslinking functionalities are provided by incorporation of one or more tetrafunctional polymerizable compounds in the amphipathic copolymer, wherein the tetrafunctional polymerizable compound is pentaerythritol tetraacrylate.

10 10. The liquid electrophotographic toner composition according to claim 1, wherein crosslinking functionalities are capable of carrying out polymerization crosslinking reactions selected from the group consisting of reaction of polyfunctional free radicals; group transfer polymerizations, ring-opening polymerization of cyclic ethers, esters, amides or acetals; epoxidations; reactions of hydroxyl or amino chain transfer agents with
15 terminally-unsaturated end groups; esterification reactions and condensation reactions.

11. The liquid electrophotographic toner composition according to claim 1, wherein crosslinking functionalities comprise isocyanate functionalities and amine functionalities that react to form polyurea linkages.

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12. The liquid electrophotographic toner composition according to claim 1, wherein crosslinking functionalities comprise isocyanate functionalities and hydroxyl functionalities that react to form polyurethane linkages.

25 13. The liquid electrophotographic toner composition according to claim 5, wherein said polyfunctional bridging compound is selected from the group consisting of divinyl benzene; 1,3 butanediol diacrylate; 1,4 butanediol diacrylate; 1,3 butanediol dimethacrylate; diethylene glycol diacrylate; diethylene glycol dimethacrylate; ethoxylated Bisphenol A diacrylate; ethoxylated Bisphenol A dimethacrylate; ethylene
30 glycol dimethacrylate (EGDMA); 1,6 hexanediol diacrylate; 1,6 hexanediol dimethacrylate; neopentyl glycol diacrylate; neopentyl glycol dimethacrylate;

polyethylene glycol diacrylate; polyethylene glycol dimethacrylate; propoxylated neopentyl glycol diacrylate; tetraethylene glycol diacrylate; tetraethylene glycol dimethacrylate; triethylene glycol diacrylate; triethylene glycol dimethacrylate; tripropylene glycol diacrylate; tripropylene glycol dimethacrylate; zinc diacrylate; zinc dimethacrylate; 1,4 phenylene diisocyanate (PDI); t-butylaminoethyl methacrylate; 5 diethylaminoethyl acrylate; diethylaminoethyl methacrylate; 2-diisopropylaminoethyl methacrylate; 2-dimethylaminoethyl methacrylate; dimethylaminopropyl methacrylamide; dipentaerythritol monohydroxypentaacrylate; 2,3-epoxypropyl methacrylate (glycidyl methacrylate); 4-hydroxybutyl acrylate; 2-hydroxyethyl acrylate; 10 2-hydroxyethyl methacrylate; 2-hydroxypropyl acrylate; cinnamyl alcohol; allyl mercaptan, methallylamine; azlactones, such as 2-alkenyl-4,4-dialkylazlactone; 2-hydroxypropyl methacrylate; meta-isopropenyldimethylbenzyl isocyanate (TMI); isocyanatoethylmethacrylate (IEM); trimethylsilylmethacrylate; (trimethylsilylmethyl)methacrylate; n-vinyl caprolactam; 2-vinyl pyridine; 4-vinyl 15 pyridine; N-vinyl-2-pyrrolidone; ethoxylated trimethylolpropane triacrylate; glyceryl propoxy triacrylate; pentaerythritol triacrylate; trimethylolpropane triacrylate; trimethylolpropane trimethacrylate (TMPTMA); tris(2-hydroxyethyl)isocyanurate triacrylate); and pentaerythritol tetraacrylate.

20 14. The liquid electrophotographic toner composition according to claim 1, wherein the D material portion of the amphipathic copolymer has a total calculated T_g greater than or equal to about 30°C.

25 15. The liquid electrophotographic toner composition according to claim 1, wherein the D material portion of the amphipathic copolymer has a total calculated T_g of from about 50-60°C.

30 16. The liquid electrophotographic toner composition according to claim 1, wherein the amphipathic copolymer has a total calculated T_g greater than or equal to about 30°C.

17. The liquid electrophotographic toner composition according to claim 1, wherein the amphipathic copolymer has a total calculated T_g greater than about 55°C.

18. The liquid electrophotographic toner composition according to claim 1, the toner
5 particle comprising at least one visual enhancement additive.

19. A method of making a liquid electrophotographic toner composition, comprising the steps of:

a) providing a plurality of free radically polymerizable monomers, wherein at
10 least one of the monomers comprises a first reactive functionality;

b) free radically polymerizing the monomers in a solvent to form a first reactive functional polymer, wherein the monomers and the first reactive functional polymer are soluble in the solvent;

c) reacting a compound having a second reactive functionality that is reactive
15 with the first reactive functionality and free radically polymerizable functionality with the first reactive functional polymer under conditions such that at least a portion of the second reactive functionality of the compound reacts with at least a portion of the first reactive functionality of the polymer to form one or more linkages by which the compound is linked to the polymer, thereby providing an S material portion polymer with
20 pendant free radically polymerizable functionality;

d) copolymerizing ingredients comprising (i) the S material portion polymer with pendant free radically polymerizable functionality, (ii) one or more free radically polymerizable monomers, and (iii) a liquid carrier in which polymeric material derived from ingredients comprising the one or more additional monomers of ingredient (ii) is
25 insoluble;

said copolymerizing occurring under conditions effective to form an amphipathic copolymer having S and D portions and to incorporate crosslinking functionality in the copolymer, the toner composition comprising crosslinking functionality in an amount sufficient to provide a three dimensional gel of controlled rigidity which can be
30 reversibly reduced to a fluid state by application of energy; and wherein the

electrophotographic toner composition does not form a film under Photoreceptor Image Formation conditions.

20. The method of claim 19, wherein the first reactive functionality is selected from
5 hydroxyl and amine functionalities, and the second reactive functionality is selected from isocyanate and epoxy functionalities.

21. The method of claim 19, wherein the first reactive functionality is a hydroxyl
10 functionality, and the second reactive functionality is an isocyanate functionality.

22. The method of claim 19, wherein the first reactive functionality is selected from
isocyanate and epoxy functionalities, and the second reactive functionality is selected
from hydroxyl and amine functionalities.

15 23. A method of electrophotographically forming an image on a substrate surface comprising steps of:
a) providing a liquid toner composition of claim 1;
b) causing an image comprising the toner particles in a carrier liquid to be
formed on a surface of a photoreceptor; and
20 c) transferring the image from the surface of the photoconductor to an intermediate transfer material or directly to a print medium without film formation on the photoreceptor.

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